A FRAME WORK OF ENHANCING NETWORK LIFE TIME WITH EFFICIENT ENERGY IN WIRELESS SENSOR NETWORK

A SYNOPSIS

Submitted by

MUTHUKKUMAR M S

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(DEEMED TO BE UNIVERSITY)

ANAND NAGAR, KRISHNANKOIL - 626126

TAMILNADU, INDIA.

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1. INTRODUCTION

1.1 Introduction

One of the most significant technological developments of the twenty-first century is wireless sensor networks (WSNs) [1]. Wireless Sensor Networks (WSNs) are gradually emerging as a fundamental component of our daily existence. Basically, it's a wireless network without infrastructure that uses a lot of wireless sensors to monitor a system, a physical environment, or something else. Due to the combination of micro electro mechanical systems (MEMS) and integrated circuits (ICs), compact sensors have emerged, as well as their actuators and electronics being consolidated into a single chip that is economically viable and high-performing. Early micro electro mechanical systems (MEMS) had many chips and packages for sensors, electronics, and mechanics. The sensor became larger, more expensive, and less productive [2]. The smart sensors serve as a node within the Wireless Sensor Network (WSN). The sensor is responsible for gathering or detecting data within the node configuration, processing it, and transmitting the information to the designated location. Power consumption, node count, sensor durability, information type and timing, location, geography, the environment, and finally the context determine how sophisticated a WSN is during its design phase. Wireless sensor networks (WSNs) rely on the collective contribution of many sensor nodes due to continuous advances in the capabilities of these miniature sensor nodes. Self-organization, multi-hop routes, dynamic network topologies, resource limitations, data-centricity, and security are the main characteristics of wireless sensor networks.

Data aggregation, power management, security administration, time-synchronization, localization, and network protocol are the main technologies of wireless sensor networks. Recent research improvements in MEMS technology, wireless communications, and digital electronics make compact, low-cost, low-power, multipurpose sensor nodes that communicate unfettered over short distances possible. Sensor networks that are specially designed to meet the distinct requirements of various sensing and monitoring applications have been the focus of extensive research in recent years.

1.2 WSN clustering

Network management issues related to energy and lifetime can be effectively managed with clustering (Afsar and Tayarani [3]). The clustering methodology employed in wireless sensor networks (WSNs) effectively conserves energy by utilizing low-cost communication methods (Rawat and Chauhan [4]). As part of the network, nodes are divided into smaller groups called clusters, and each cluster is assigned a cluster head (CH) for the purpose of monitoring the activities of each cluster (Zhang and Chang [5]). The CHs also have the option of forming their own group in order to reach the BS in a multi-hop pattern. The sensed data from the nodes is collected by the cluster head (CH) in order to communicate with the base station (BS) (Bongale et al.[6] and Rawat et al.[7]). To optimize network energy consumption, the Cluster Head (CH) employs aggregation methods to eliminate redundancy from the accumulated data (Massad et al.[8]).

1.3 Clustering characteristics

Clustering and routing algorithms offer a range of benefits, including as fault tolerance, scalability, increased network lifetime, reduced delay, minimized energy consumption, collision avoidance, effective coverage and connectivity management, load balancing, and data aggregation, etc (Fanian et al.[9]). The main purpose of cluster-based approaches is to enhance network performance. Figure. 1 illustrates the characteristics of the clustering approaches in Wireless Sensor Networks (WSN).

The existing CH selection procedure fails to effectively utilize the energy of nodes, resulting in a negative impact on network performance. But still, improvisation is required in terms of energy consumption and computational complexity. This research proposed the Quasi Oppositional based Jaya Load Balancing Strategy with Cluster Head (QOJ-LCH) selection protocol. Its objective is to enhance the network's lifespan and optimize energy consumption.

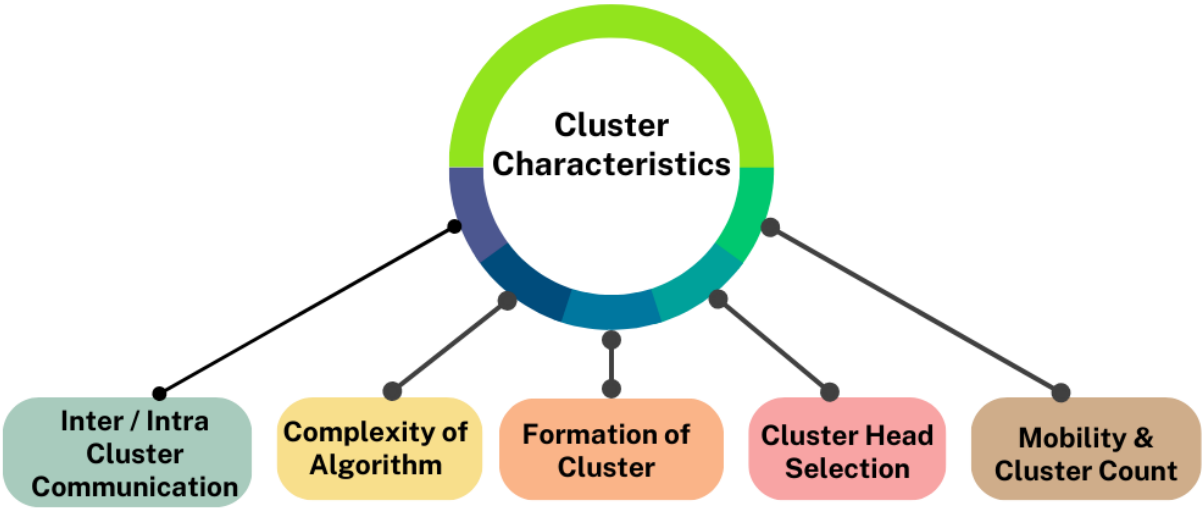

Figure. 1. Shows the important characteristics of clustering protocols. (Piyush and Siddhartha [10]).

Section 2 explains the literature review and problem statement, Section 3 explains the scope of the research work, and then the research contribution is explained in Section 4, thesis organization is presented in Section 5, proposed methodologies is presented in Section 6, and result of the proposed work is explained in Section 7. This proposed work is concluded with Performance analysis in Section 8.

2. LITERATURE REVIEW

As WSNs have become increasingly prevalent across a wide range of industries, they offer valuable contributions to a variety of fields. A wide range of services are offered on this platform, which encompasses a number of applications suggested for Wireless Sensor Networks (WSNs), including environmental monitoring Rashid & Rehmani [11], healthcare Noel [12], smart homes Chitnis et al [13], smart industries Aalsalem [14], disaster management Mangla et al.[15], military operations, and agriculture. The structure of WSNs is considered highly dynamic, but managing the network's resources and making the network scalable, reliable, and efficient have been a major challenges Meena [16]. It is common for Wireless Sensor Networks (WSNs) to include a large number of low-cost, multifunctional sensor nodes that typically run on limited battery power and are deployed to monitor a region of interest Zheng & Jamalipour [17]; Chuan et al.[18]; Raghavendra et al. [19]; Akkaya & Younis, [20]). These sensors are capable of detecting external occurrences,

analyzing their results, and transmitting them. A Wireless Sensor Network (WSN) contains essential components, including batteries, memory, processors, and radio modules to facilitate communication García-hernández [21].

Wireless connections provide a connection between a large number of these diminutive sensors, which are characterized by their small physical dimensions and possess integrated micro-controllers and radio transceivers that collectively form a Wireless Sensor Network (WSN) Sinha & Lobiyal[22]; Kaur & Mahajan[23]; Krishnan et al.[24]; Saini et al.[25]; Wireless Sensor Network (WSN) sensors have the capability to perceive and identify activity inside their designated sensing region. Furthermore, these sensors are equipped to send pertinent information, engage in data processing, and establish communication with other WSN sensors Yick et al. [26]. The implementation of sensors in Wireless Sensor Networks (WSN) can be carried out using either manual or random methods.

While designing wireless sensor networks (WSNs) there are numerous research challenges. One of the most critical considerations in the field of Wireless Sensor Networks (WSNs) is the need to extend the operational lifespan of both the sensor nodes and the entire network. This necessitates a primary focus on reducing energy consumption. According to Chowdhury, Hossain [27], one of the primary factors contributing to the energy limitations of sensor nodes is their restricted power capacity. Furthermore, the feasibility of recharging or changing the battery in the sensor nodes is often limited. Hence, it is imperative to identify appropriate methodologies for the preservation of energy in these nodes. Sensing, processing, and communication represent the primary contributors to energy usage within sensor nodes. Among the three aforementioned operations, it can be observed that communication consumes a greater amount of energy in comparison to the remaining two actions. The literature presents various approaches for mitigating energy usage and enhancing the longevity of a Wireless Sensor Network (WSN). This thesis examines the energy conservation strategies provided by several scholars with the aim of enhancing the longevity of wireless sensor networks.

2.1 Problem Statement

The literature listed above highlights that energy efficiency, longevity, and network stability are significant concerns within the domain of wireless sensor networks (WSN). However, a number of solutions have already been offered for

addressing these concerns; nevertheless, there remain certain unresolved issues that have been noted and are outlined below.

- The majority of solutions suggested for clustered networks primarily focus on the overall network structure and do not take into account the specific application aspect of this approach.
- The protocols utilized in the clustering domain are founded upon the execution of clustering activities in each round, resulting in an escalation of complexity and delay within the protocols.
- Many protocols are specifically designed to function effectively within smaller networks and may not be able to adequately accommodate larger network sizes or increased numbers of nodes.
- The existing CH selection procedure fails to effectively utilize the energy of nodes, resulting in a negative impact on network performance.
- The existing research utilizes the LBC-COFL algorithm to address the issue of energy consumption.

3. SCOPE OF RESEARCH

A careful analysis of these issues in wireless sensor networks (WSN) has led to the development of the below-proposed techniques to address them.

- The proposed method is the Quasi Oppositional based Jaya Load Balancing Strategy with Cluster Head (QOJ-LCH) selection protocol. Its objective is to enhance the network's lifespan and optimize energy consumption.
- Quasi-oppositional (QO) population is used to create the initial population, which accelerates the rate of convergence in QOJ-LCH.
- A metaheuristic-based approach is implemented in this research to balance loads in an energy-efficient manner.
- Furthermore, it lowers the cost of inter-cluster communication between nodes. The proposed SSA-TSA is a superior option regarding network dependability, energy efficiency, lifetime, and network stability.
- The SSA-TSA clustering algorithm has been utilized in the WSN with cluster head selection to maximize energy efficiency.
- The Sparrow Search’s strength and Tabu Search (SSA) are utilized to determine the most efficient route from the source node, CH, to the

destination node, BS. This algorithm is particularly advantageous in wireless sensor networks (WSN) as it facilitates the rapid identification of optimal solutions.

- Due to its capacity for efficient resource allocation, adaptability to shifting circumstances, and low communication overhead, this algorithm is a promising method for improving the efficiency and scalability of wireless communication systems.

4. CONTRIBUTION

1. Initially development of Efficient Load Balancing in WSN Using Quasi – oppositional Based Jaya Optimization with Cluster Head Selection.

2. To improve the adaptability and durability of wireless sensor networks using Stochastic Diffusion Hunt Optimization (SDH) methods.

3. Finally, optimize the utilization of resources and enhance the efficiency of the network by adjust the creation of clusters using Sparrow Search Algorithm in conjunction with Tabu Search Clustering (SSA-TSA).

5. ORGANIZATION OF THESIS

The research work is organized into four chapters and is as follows:

Chapter.1 – Introduction.

Chapter.2 – Deals with literature survey.

Chapter.3 –Deals with design and implementation of efficient Load Balancing in WSN.

Chapter.4 –Discussed exploration on reusability of clusters

Chapter.5 –Discussed an optimization method to enhance the efficiency of the network

Chapter 6 – Concludes the research methodology with future aspects.

6. PROPOSED METHODOLOGIES

A. Efficient Load Balancing in WSN Using Quasi – oppositional Based Jaya Optimization with Cluster Head Selection

The effective utilization of energy is a significant challenge in the context of Wireless Sensor Network (WSN) systems. Various clustering strategies have been employed to provide load balancing in Wireless Sensor Network (WSN) systems. In the framework of clustering, the cluster head (CH) is chosen as a relay node with higher power in comparison to the non-CH nodes. The suggested system employs the Quasi oppositional based Jaya load balancing method with cluster head (QOJ-LCH) selection procedure in order to enhance the longevity of the network and reduce energy consumption. The QOJ-LCH approach enhances the longevity of relay nodes and promotes equitable distribution of the load on relay nodes throughout the network, hence improving their lifespan. The system demonstrates enhanced performance, scalability, and dependability. The architectural process of QOJ-LCH, including the selection of cluster heads, is depicted in Figure 2.

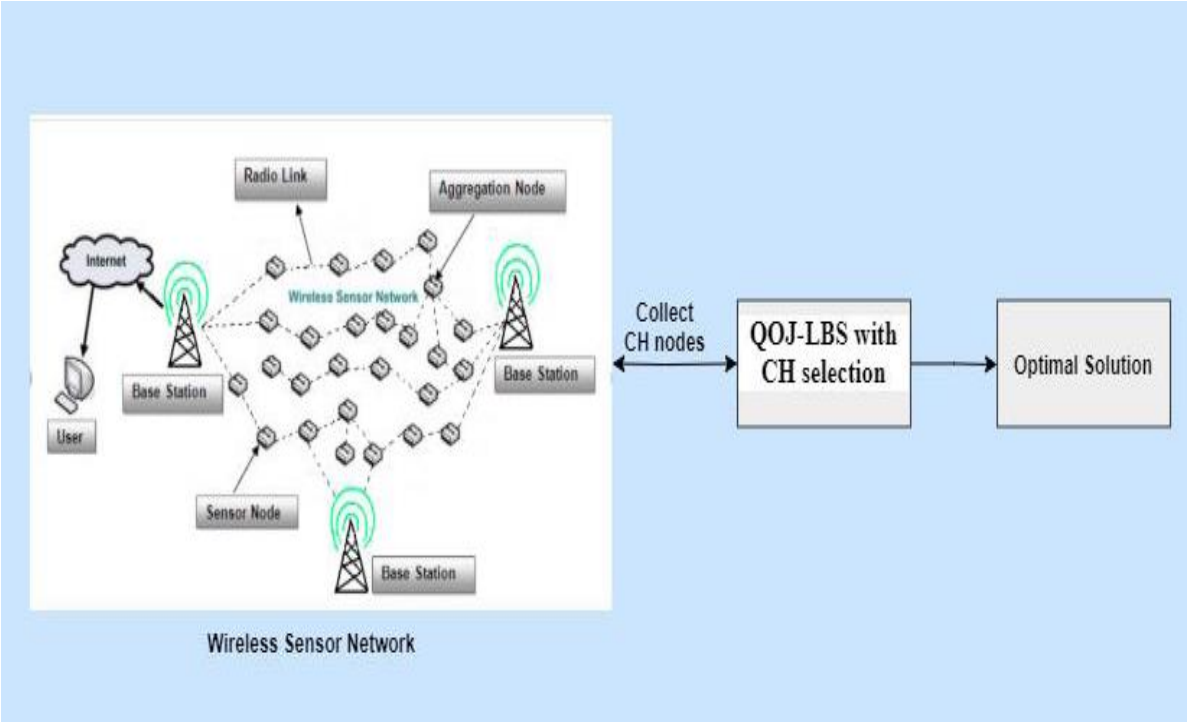

Figure.2. Architecture of QOJ-LCH with Cluster Head Selection.

Energy Model

In this model has resemblance to the energy model employed in the communication channel. The system has two distinct channels, namely the free space channel and the multi-path channel. The energy model utilizes DE to represent the transmitter and receiver, as shown in equations (1) - (3) [18]. The threshold value is represented as Dh0 and then the free-space and multi-path channel is selected.

$$EN_{tx}(k_b, DE) = \begin{cases} Kb * EN_{elec} + Kb * \epsilon_{FS} * D^2, DE < Dh_0 \\ Kb * EN_{elec} + Kb * \epsilon_{MP} * D^4, DE \geq Dh_0 \end{cases} \quad (1)$$

Where EN_{elec} is represented as the amount of usage consumed by the electric circuit, $\epsilon_{FS}$and $\epsilon_{MP}$is denoted as energy taken by transmitters is spacious and multi-path channel.

$$ENrx(Kb) = kb * EN_{elec} \quad (2)$$

$$D_0 = \sqrt{\frac{\epsilon_{FS}}{\epsilon_{MP}}} \quad (3)$$

D_0 denotes the threshold value Kb is a data bit is used above the distance of D

B. Stochastic diffusion hunt optimization for potential load balancing in wireless sensor networks

The use of Stochastic Diffusion Hunt Optimization (SDH) presents an effective approach for improving the adaptability and durability of wireless sensor networks. This study employs a Synchronous Digital Hierarchy (SDH) algorithm to enhance the efficiency of power utilization in the sensor network architecture and achieve a more balanced network load. In the context of SDH optimization, the diffusing approach is employed to determine the most suitable cluster heads (CHs) and establish effective routing pathways. The rapid convergence of the technique may be attributed to the use of SDH operators, which are characterised by a specific robustness function that takes into account low power consumption, load distribution, and novel resolution criteria. Moreover, it is proposed to implement an adaptive round period that incorporates power management and load balancing in network architecture. This approach aims to prevent clusters from encountering any network overhead by further reducing the energy consumption of sensor nodes.

C. Optimal Metaheuristic Sparrow Tuba Search Clustering for Load Balancing in Wireless Sensor Networks

The exponential growth of diverse wireless devices and the increasing need for high data rates have presented significant challenges, particularly in the effective

implementation of load balancing mechanisms to ensure equitable allocation of network resources among various nodes. In order to enhance the longevity of the network while minimizing energy usage, the present study employs the Sparrow Search Algorithm in conjunction with Tabu Search Clustering (SSA-TSA).

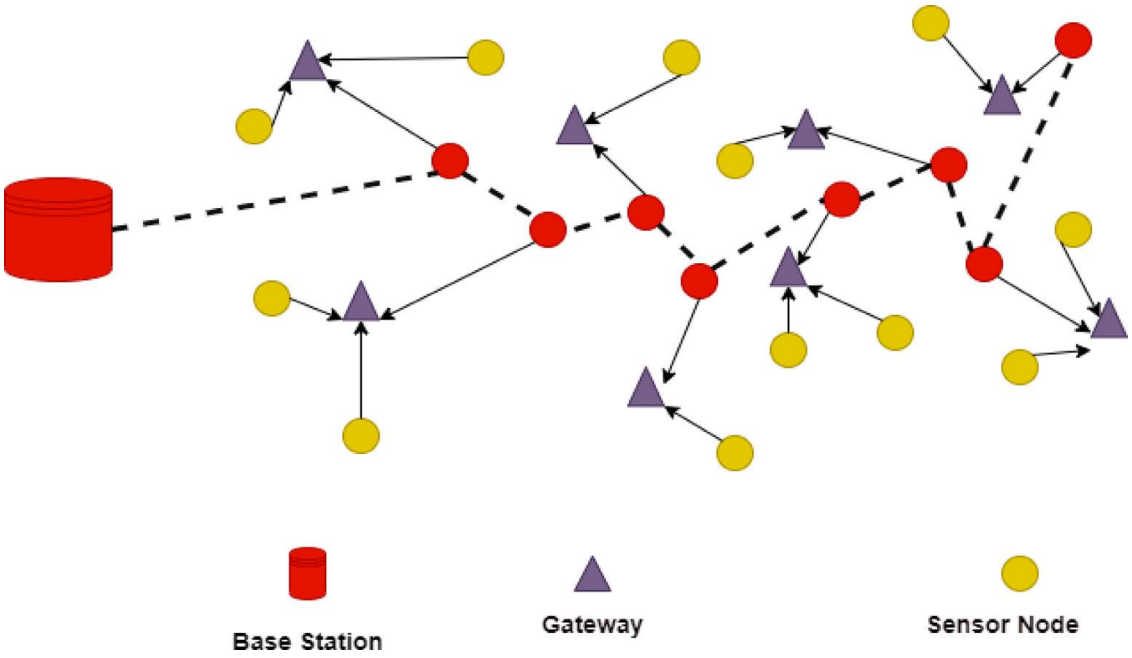

Figure.3. SDH cluster head selection and optimal routing path.

The algorithm adaptively adjusts the creation of clusters in order to optimize the utilization of resources and enhance the efficiency of the network. The findings demonstrate that the proposed SSA-TSA surpasses the present techniques in load balancing, producing a more even distribution of network traffic and boosting total throughput. Furthermore, the use of the SSA-TSA combination results in reduced energy consumption and enhanced activation of nodes compared to conventional methods such as GWO and improved GWO.

Metaheuristic-based Tabu Search Clustering Algorithm

A metaheuristic algorithm is employed to address optimization issues by offering an optimal solution. It is also referred to as an optimization-based clustering method. The purpose of this tool is to identify the most optimized solution [20].

Algorithm : Tabu Search Algorithm

Step 1: Randomly Initialization of clusters $\{cl'_1, cl'_2, \ldots, cl'_n\}$.
Step 2:$it = 0$
Step 3:$tbl = \emptyset$
Step 4: while $it < \max_iter$ do
Step 5:$it = it + 1$
Step 6: Create neighbhourhood set for the current solution $N(cl')$ of $N(cl', tbl)$.
Step 7: FOR each node in the cluster $cl'_j \in N'$ do
Step 8: IF $cl'_j \notin tbl$ then
Step 9: Evaluate $F(cl'_j)$
Step 10:$cl^* = cl'_j \mid F(cl^*) < F(cl'_j)$
Step 11: End If
Step 12: End For
Step 13:$tbl = tbl \cup \{cl^*\}$ //Add current new solution into tabu list.
Step 14:$it++$
Step 15: End While

7. RESULTS AND DISCUSSION

The evaluation result of the proposed Quasi oppositional based Jaya load balancing strategy (QOJ-LCH) with cluster head (CH) selection protocol method uses many comparative parameter metrics such as active sensor nodes, network energy consumption, lifespan of the network, lifetime of relay nodes in each circle.

7.1. Evaluation of Single-hop Routing and Multi-hop Routing

This study presents the Quasi oppositional based Jaya load balancing approach (QOJ-LCH) together with a cluster head (CH) selection procedure, in which relay nodes transfer data directly to the sink. The primary concern is to enable the sensor nodes located on the transfer nodes to reduce the overall power consumption of the transfer nodes. The system operates effectively when utilising a configuration consisting of 15 to 20 relay nodes.

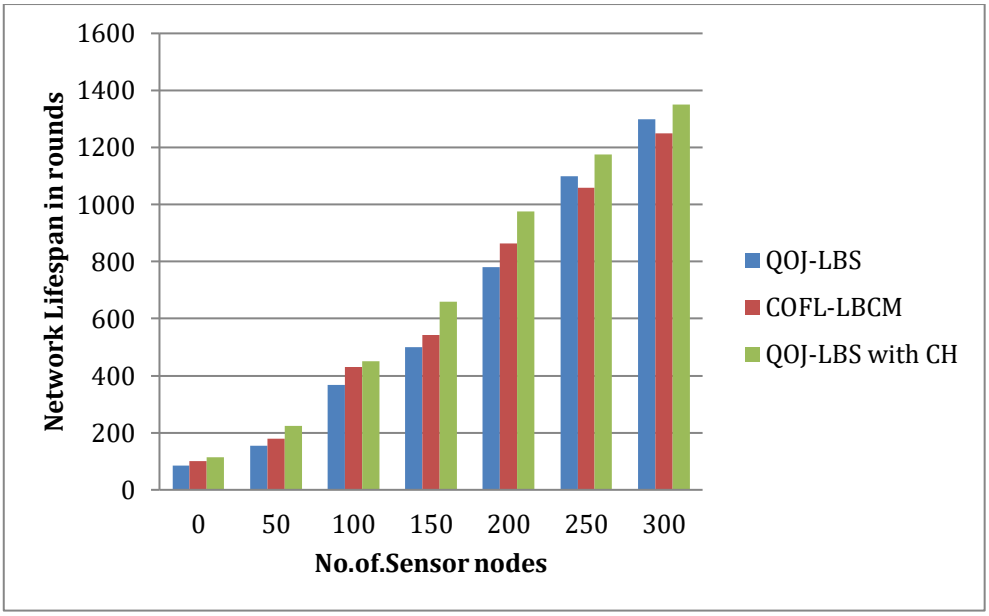

Figure.4. Network lifespan for Single-hop.

Figure 4, shows the proposed QOJ-LCH with CH selection improves the lifespan in Multiple-hop routing. It worked with 1800 rounds in network and 350 sensor nodes. It achieves better performance compared with the existing algorithms such as QOJ-LCH, COFL-LBCM. Also compared with single-hop routing, the multi-hop routing achieves more lifespan of the network.

7.2 Aanlysis of lifetime of network

The SSA-TSC technique was built using MATLAB R2018a. The tests were conducted using a total of 1500 nodes, each having an initial energy level of 0.3 Joules. This study presents a comparative analysis of the suggested work with existing algorithms, namely tablu search (TS) [23], Sparrow search algorithm (SSA) [24], and Particle Swarm Optimisation (PSO) [25]. The life time of nodes in the network is calculated based on the initial energy and also consumption of energy. Figure.5 shows the analysis of the lifetime of a network in the aspect of the alive node.

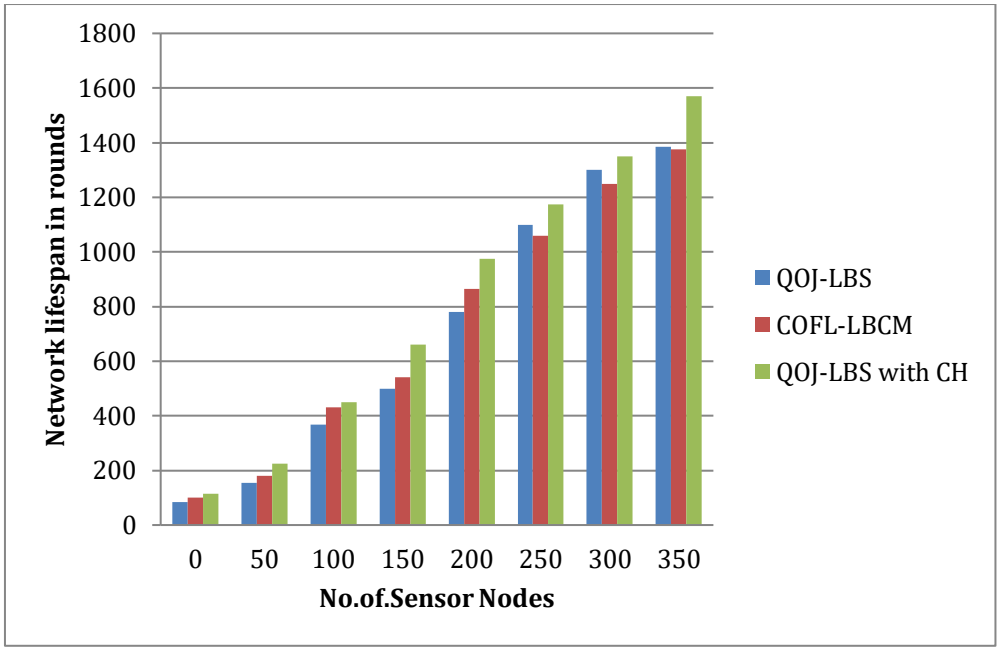

Figure.5. Network lifespan for Multiple-hop.

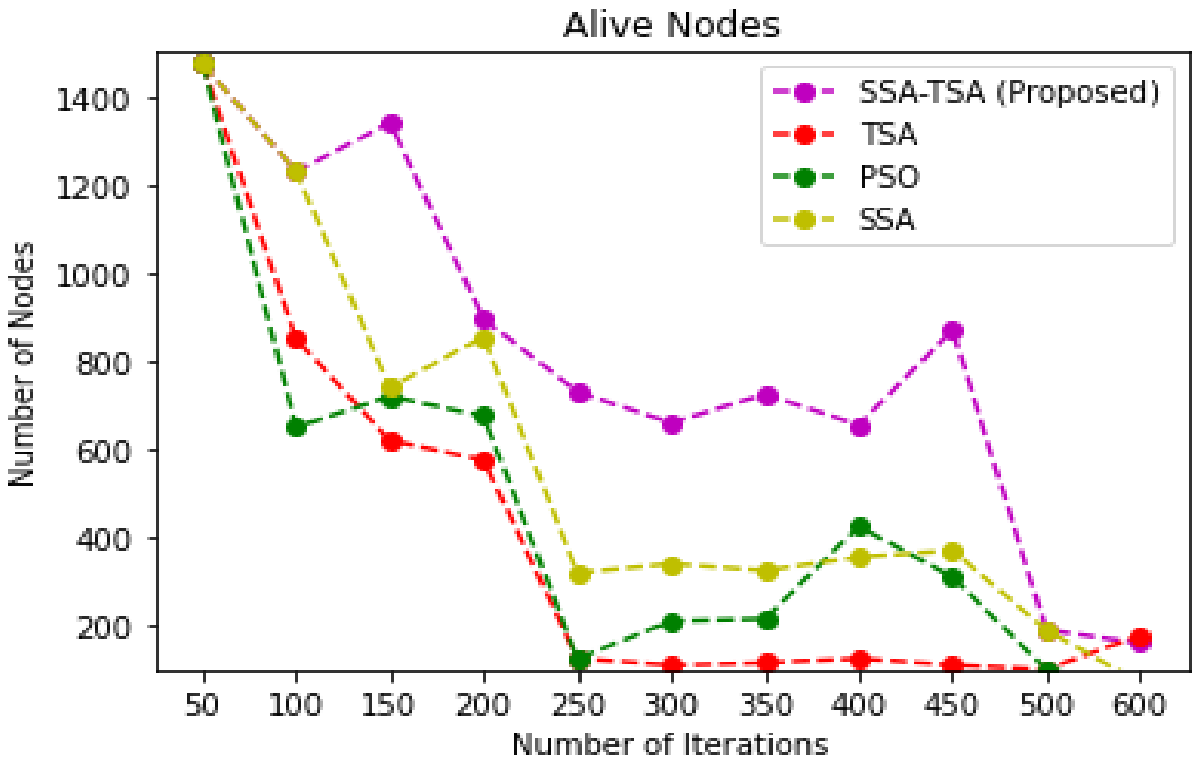

Figure.6. Alive Node of different methods.

Figure.6 illustrates that the number of alive nodes in the network gets reduced in TSA, PSO, and SSA. But SSA-TSA has maximum stability of the network and increased its network lifetime. Similarly, the performance of the proposed algorithm is also

compared with recently developed high performed algorithms such as CRCGA, LEACH, GECR, OMPFM, and GADA-LEACH. Figure.7. depicts the average end-to-end delay transmission of SDH by 0.007 seconds less when compared with CRCGA, LEACH, GECR, OMPFM, and GADA-LEACH, respectively, with various nodes.

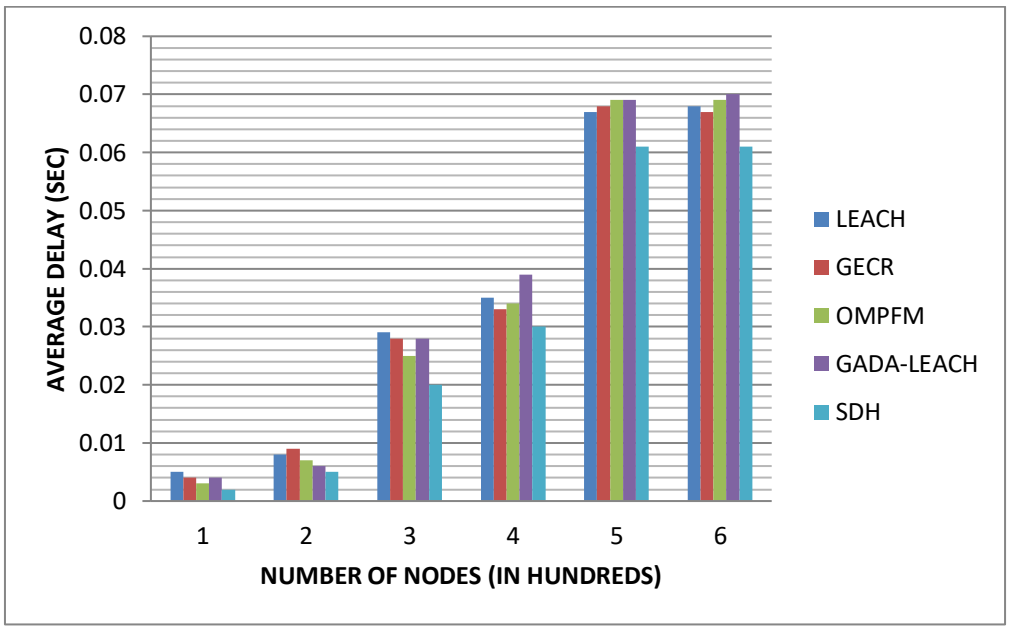

Figure.7. Average delay of data transmission

8. CONCLUSION

In order to ensure the correct and efficient operation of Wireless Sensor Networks (WSNs), the preservation of energy is a fundamental necessity. Due to the prevalence of technological issues and the need for efficient resource allocation, significant attention is being devoted to the issue of energy consumption. The QOJ-LCH method improves the minimum lifetime relay node and shares the load on relay nodes equitably across the network to enhance the lifespan. It also reduces the load-balancing problems in Wireless Sensor networks. It uses two routing methods single-hop and multiple-hop. It works with fitness function and gives the best and worst candidate population over the network. The head selection at cluster helps to improve the lifespan of the network. The proposed QOJ-LCH with CH selection method enhances the lifespan of the network, total energy consumption, the standard deviation of the relay node and the entire amount of active sensor nodes present in the WSN. Moreover, the proposed work SSA-TSA approach is easily adaptable and it is used in various network structures in various numbers of nodes. A detailed

performance analysis is carried out and produces a prominent result for our proposed work SSA-TSA. In the future, it can be implemented by enhancing the collection of data in various forms, sources, and additional sensor devices.

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LIST OF PUBLICATIONS

1. “Stochastic diffusion hunt optimization for potential load balancing in Wireless Sensor Networks” Materials Today Proceedings – Scopus Indexed March 2023.
2. “Efficient Load Balancing in WSN Using Quasi – Oppositional Based Jaya Optimization with Cluster Head Selection” International Journal of Computer Network and Information Security – Scopus Indexed April 2023.
3. “Optimal Metaheuristic Sparrow Tuba Search Clustering for Load Balancing in Wireless Sensor Networks” Ad Hoc & Sensor Wireless Network – SCI Indexed October 2023.
4. “Self Asserted Power Optimization Protocol for Heterogeneous WSN” IEEE Xplore – Scopus Indexed August 2023.